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IPv6 and Interoperability

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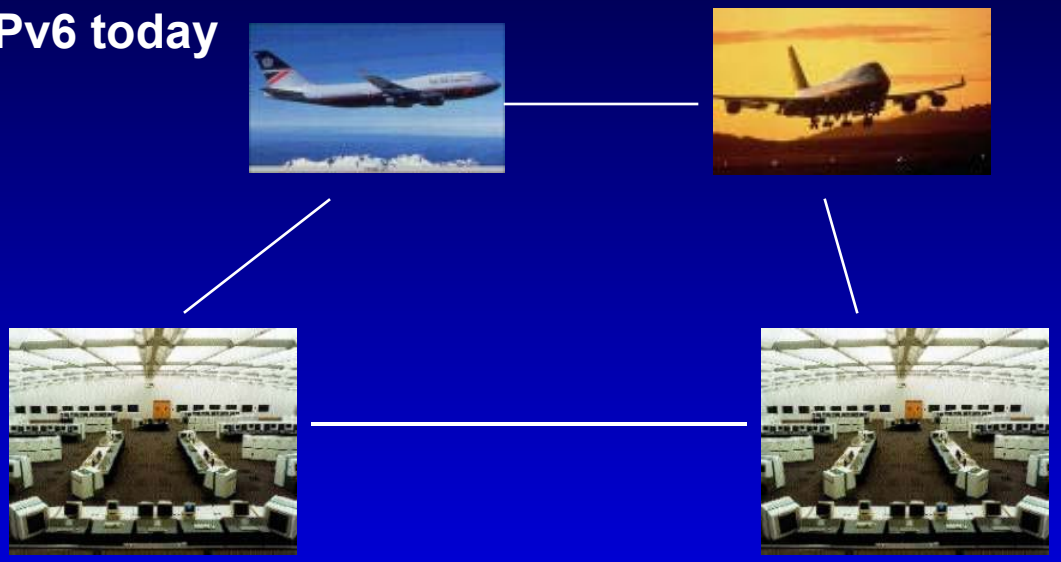
Agenda

- Motivation
- Interoperability and the DoD
- What is IP
- What is IPv6
- IPv6 and ATMS
- What is next?
- Summary
- Further Work

Motivation

- Why are we interested in IPv6 today
  - Interoperability



  - Cost savings
- But what are the issues

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What we know

There are many network approaches and protocols in use today

Commerce has standardized on IPv4

IPv6 is an evolutionary step for the Internet Protocol (IP)

It is already being widely supported by routers and operating systems

Is IPv6 ready for prime time?

Interoperability and the DoD

- Joint Vision (JV) 2010 and JV 2020
  - Interoperability

DoD Level Documents

Transformation Planning Guidance: Clear, concise approach for transforming the Department of Defense.(Apr 03)

Joint Vision 2020: CJCS's vision for the 21st Century supercedes JV 2010 that was released in July 1996. Concept for Future Joint Operations (CFJO).

Army Vision 2010: CSA's vision for land warfare in support of JV2020.

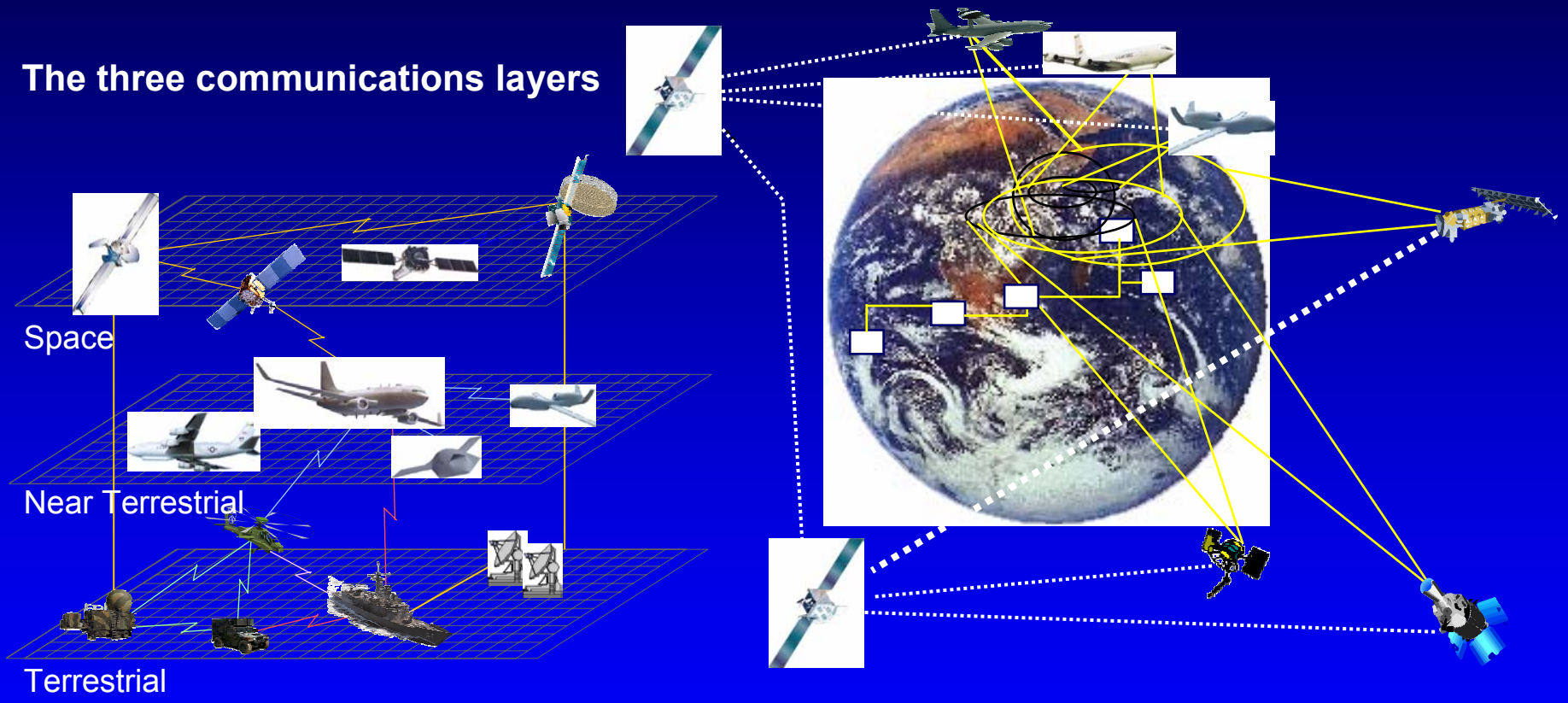
Sea Power 21: CNO's vision for maritime operations in the 21st Century.

Operational Maneuver From the Sea: Commandant's vision for Marine Corp's projection of naval power ashore.

Air Force Vision 2020: CSAF Vision for Air Operations into the 21st Century.

The Services have a "common" view of the future

Global Information Grid



A Single Communications Grid

Net Centric Operations and Warfare

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Get the right information

to the right people

at the right time

and the right media

in the right language

at the right level of detail

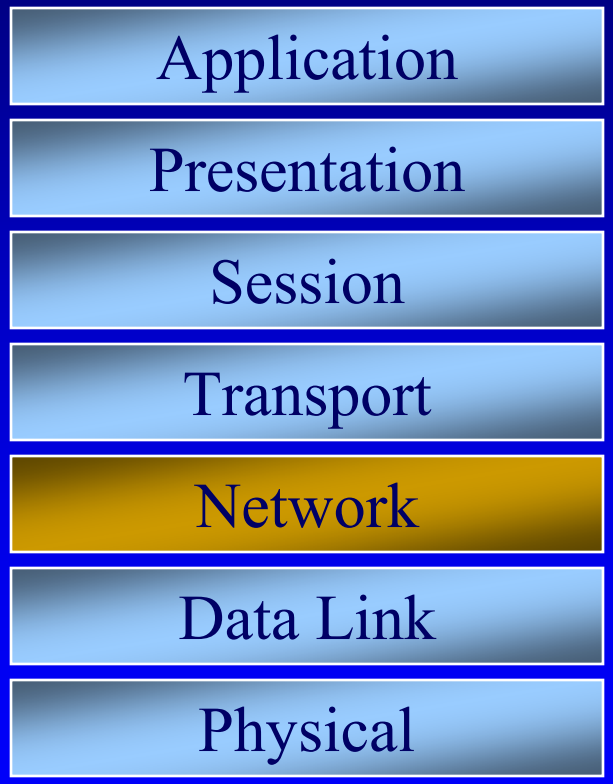
The lexicon to the GIG

Interoperability Enabler

- **John Stenbit, Assistant Secretary of Defense for Networks and Information Integration (October 2003)**
  - Interoperability needs to be ‘smart pull’ based – get info when you need it
  - IPv6 is needed for addressability, QoS, and mobility
  - All future systems must support IPv6

What is IP

- Internet Protocol
  - Current standard IPv4
- Ubiquitous protocol
- IP fits within the OSI stack and hence applications are insulated from
  - Medium – copper, coax, wireless, satellite
  - Datalink – Ethernet
- Applications are type agnostic
  - Email, small data files
- IPv4 does not provide native support for
  - Audio, VoIP, Video
  - QoS (Quality of Service)
  - Security
  - More than 2^{32} end user devices



What is IPv6

- IPng (Internet Protocol next generation)

- Larger address space ($2^{128\ \text{fixed}}$)
- Autoconfiguration (plug and play)
- Security
- QoS support
- Supports mobility (MIPv6)
- Enhanced Management

- Unify intranets and internet

Quality of Service (QoS)

- Give better service to some traffic at the expense of others
- Address Latency
  - Define delivery window
  - Priority Scheme
- Enables
  - VoIP (quality, dropout)
  - System critical traffic

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Security

- IPSec built-in
- HAIPE (High Assurance Internet Protocol Encryptor)
  - NSA's IPSEC

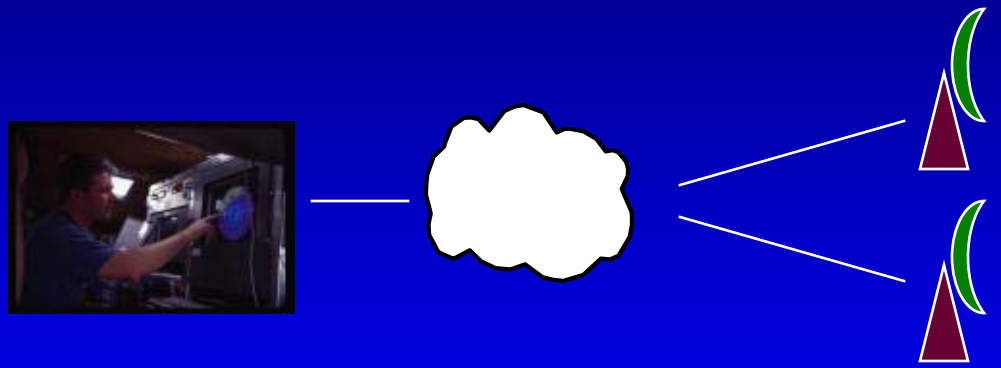
IPv6 and Mobile

- Mobile IPv6 (MIPv6) Standard
  - enables network-application users to transparently roam between wired, wireless, and cellular networks without dropping their connections

- Wireless Internet
  - On-line
  - Sensors (Homeland Security, Medical, Sports)
  - Entertainment (Back of bus)

IPv6 and ATMS

- Internal networks are IP based
  - Heavily customized (multiple networks) for high reliability
  - No single point of failure
- Ground-Ground
  - Radar (near real time)



  - Flight Plans (before needed)
  - Weather distribution (fused weather products)
  - Intercenter voice communication
  - Flow Management

IPv6 and ATMS

- Ground-Air
  - Voice
  - Data (CPDLC)
  - Weather (Ground/Air based)
- Air-Air
  - Situational awareness (ADS-B)
  - 4D Trajectories
- IPv6 addresses these issues

Internet Protocol for Aeronautical Exchange (iPAX)

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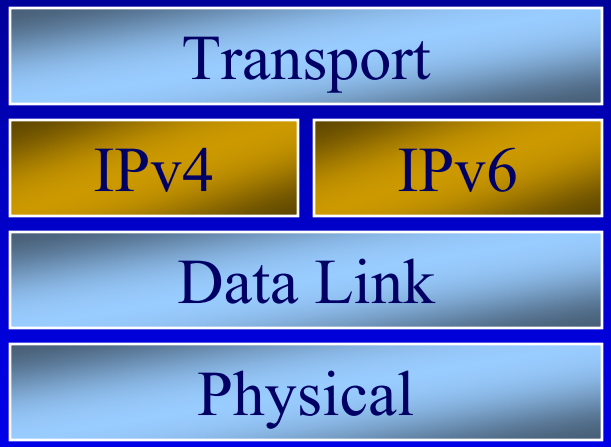
- Eurocontrol initiative
  - X.25 Telecommunication Equipment no longer sold – supported only until end 2005
- IP activity
  - OLDI (European Air Traffic Services Inter-facility Data Communications equivalent) ported to IP, pre-trials successful
  - Surveillance – ASTERIX over IP
  - AFTN/CIDIN migrating to X.400 over IP
- Approach
  - IPv6 Backbone
  - International inter-center coordination
  - Gateways to existing local networks (IPv4, X.25, …)
- Moving at high speed

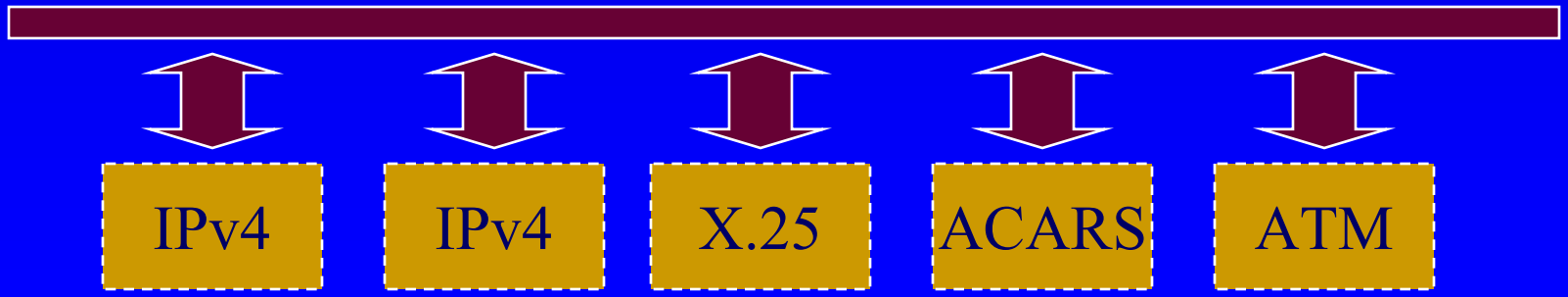
Migration Strategies

- IPv6 over IPv4 tunnels

- Dual Stacks



- Gateways



What's Next

- Is IPv6 the end?

What about IPv8?

- DARPA are looking at removing the stack and replacing it with a mesh
  - Wireless communications access OSI layers directly

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Summary

- Industry Support
  - Major vendors
  - Industries (Medical -> Space)
- Incremental upgrade to IPv4
  - Not radical change in infrastructure
- DoD Net-Centric Operations and Warfare
  - Huge driving force for standardization
- Air Transportation Ground Infrastructure can benefit from commercial industries
- Mobile internet
  - 4G
  - Back of Bus

But …

Further Work

- Issues
  - Latency (QoS is good, but is it fast enough)
  - Security (vs. Latency)
  - Migration Strategies
  - Mobility (narrow band vs. broadband)

Glossary

- ESP Encapsulation Security Protocol
- HAIPE High Assurance Internet Protocol Encryptor
- ICMP Internet Control Message Protocol (ICMP) Network operation messages
- IETF Internet Engineering Task Force
- IP Internet Protocol
- IKE Internet Key Exchange
- IPsec IP Security Protocol
- NAT Network Address Translation

Backup - Technical Details

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IPv6 General Characteristics

- Larger address space (IPv6 introduces Anycast addresses)
- Unify intranets and internet
- Use LANs better (neighbor discovery replaces ARP)
- Security (better management of Source Routing)
- Routing
  - Plug and Play (auto configuration mechanisms)
  - QoS support
  - Supports mobility (MIPv6) ****
  - Supports priorities
- Support ATM
  - Concept of Flow
  - QoS
- Transition from IPv4 to IPv6
  - Concept of dual stack
  - Gateways

IPv4 and IPv6 Differences

IPv4	IPv6
Addresses are 32 bits in length	Addresses are 128 bits in length
IPSec support is optional	IPSec support is required
No identification of packet flow for QoS handling by routers is present within the IPv4 header	Packet flow identification for QoS handling by routers is included in the IPv6 header using the Flow Label field
Fragmentation is done by both routers and the sending host	Fragmentation is not done by routers, only by the sending host
Header includes a checksum	Header does not include a checksum
Header includes options	All optional data is moved to IPv6 extension headers
Address Resolution Protocol (ARP) uses broadcast ARP	ARP Request frames are replaced with multicast Neighbor Solicitation messages
Internet Group Management Protocol (IGMP) is used to manage local subnet group membership	IGMP is replaced with Multicast Listener Discovery (MLD) messages
ICMP Router Discovery is used to determine the IPv4 address of the best default gateway and is optional	ICMP Router Discovery is replaced with ICMPv6 Router Solicitation and Router Advertisement messages and is required
Broadcast addresses are used to send traffic to all nodes on a subnet	There are no IPv6 broadcast addresses. Instead, a link-local scope all-nodes multicast address is used
Must be configured either manually or through DHCP	Does not require manual configuration or DHCP
Must support a 576-byte packet size (possibly fragmented)	Must support a 1280-byte packet size (without fragmentation)

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Types of IPv6 Addresses

- Unicast: A unicast address identifies a single interface within the scope of the type of unicast address. Packets addressed to a unicast address are delivered to a single interface.
- Multicast: A multicast address identifies multiple interfaces. Packets addressed to a multicast address are delivered to all interfaces that are identified by the address. A multicast address is used for one-to-many communication, with delivery to multiple interfaces.
- Anycast: An anycast address identifies multiple interfaces. Packets addressed to an anycast address are delivered to a single interface, the nearest interface that is identified by the address. The “nearest” interface is defined as being closest in terms of routing distance. An anycast address is used for one-to-one-of-many communication, with delivery to a single interface.

IPv6 Main Address Types

Allocation	Prefix	Fraction of Address Space
Global Unicast addresses	**001**	**1/8**
Link Local addresses	**1111 1110 10**	**1/1024**
Site Local addresses	**1111 1110 11**	**1/1024**
Multicast addresses	**1111 1111**	**1/256**

IPv4 and IPv6 Headers

- IPv6 Header

Version	Class	Flow Label	
Payload Length		Next Header	Hop Limit
Source Address			
Destination Address			

- IPv4 Header

Version	IHL	Type of Service	Total Length	
Identification			Flags	Fragment Offset
Time-to-live		Protocol	Header Checksum	
Source Address				
Destination Address				
Options				Padding

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IPv4 Header Fields and IPv6 Equivalents

IPv4 Header Field	IPv6 Header Field
Version	Same field but with different version numbers.
Internet Header Length	Removed in IPv6. IPv6 does not include a Header Length field because the IPv6 header is always a fixed size of 40 bytes. Each extension header is either a fixed size or indicates its own size.
Type of Service	Replaced by the IPv6 Traffic Class field.
Total Length	Replaced by the IPv6 Payload Length field, which only indicates the size of the payload.
Identification Fragmentation Flags Fragment Offset	Removed in IPv6. Fragmentation information is not included in the IPv6 header. It is contained in a Fragment extension header.
Time to Live	Replaced by the IPv6 Hop Limit field.
Protocol	Replaced by the IPv6 Next Header field.
Header Checksum	Removed in IPv6. In IPv6, bit-level error detection for the entire IPv6 packet is performed by the link layer.
Source Address	The field is the same except that IPv6 addresses are 128 bits in length.
Destination Address	The field is the same except that IPv6 addresses are 128 bits in length.
Options	Removed in IPv6. IPv4 options are replaced by IPv6 extension headers.

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Header Types

- Look in packet for next header
  - Can be Extension Header
  - Can be something like ICMP, TCP, UDP, or other normal types

Header Types

Decimal	Keyword	Header Type
0		Reserved (IPv4)
0	HBH	Hop-BY-Hop options (IPv6)
1	ICMP	Internet Control Message (IPv4)
2	IGMP	Internet Group Management (IPv4)
2	ICMP	Internet Control Message (IPv6)
3	GGP	Gateway-to-Gateway Protocol
4	IP	IP in IP (IPv4 encapsulation)
5	ST	Stream
6	TCP	Transmission Control
---	---	----------
17	UDP	User Datagram

Header Types

Decimal	Keyword	Header Type
29	ISO-TP4	ISO Transport Protocol Class
---	---	----------
43	RH	Routing Header (IPv6)
44	FH	Fragmentation Header (IPv6)
45	IDRP	Inter-domain Routing Protocol
---	---	----------
51	AH	Authentication Header
52	ESP	Encrypted Security Payload
---	---	----------
59	NULL	No next header (IPv6)
---	---	----------

Header Types

Decimal	Keyword	Header Type
80	ISO	ISO Internet Protocol (CLNP)
---	---	----------
88	IGRP	IGRP
89	OSPF	OSPF
---	---	----------
255		Reserved

Neighbor Discovery

- Neighbor Discovery Protocol replaces ARP (Address Resolution Protocol)
- ICMP (Internet Control Message Protocol) Neighbor Solicitation and Neighbor Advertisement messages are used to allow all nodes (hosts and routers) to learn mappings between IPv6 addresses and link addresses
- ICMP Router Advertisement allows nodes to know all routers that are available on the link automatically. Hosts build Default Router List based on these advertisements (No manual configuration)

IPv6 Neighbor Discovery Processes

Process	Description
Router discovery	The process by which a host discovers the local routers on an attached link. Equivalent to ICMPv4 Router Discovery.
Prefix discovery	The process by which hosts discover the network prefixes for local link destinations. Similar to the ICMPv4 Address Mask Request/Reply.
Parameter discovery	The process by which hosts discover additional operating parameters, including the link MTU and the default hop limit for outgoing packets.
Address autoconfiguration	The process for configuring IP addresses for interfaces in either the presence or absence of a stateful address configuration server such as Dynamic Host Configuration Protocol version 6 (DHCPv6).
Address resolution	The process by which nodes resolve a neighbor's IPv6 address to its link-layer address. Equivalent to ARP in IPv4.
Next-hop determination	The process by which a node determines the IPv6 address of the neighbor to which a packet is being forwarded based on the destination address. The forwarding or next-hop address is either the destination address or the address of an on-link default router.
Neighbor unreachability detection	The process by which a node determines that the IPv6 layer of a neighbor is no longer receiving packets.
Duplicate address detection	The process by which a node determines that an address considered for use is not already in use by a neighboring node. Equivalent to using gratuitous ARP frames in IPv4.
Redirect function	The process of informing a host of a better first-hop IPv6 address to reach a destination. Equivalent to the use of the IPv4 ICMP Redirect message.

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IPv4 Concepts and IPv6 equivalent

IPv4 Address	IPv6 Address
Internet address classes	Not applicable in IPv6
Multicast addresses (224.0.0.0/4)	IPv6 multicast addresses (FF00::/8)
Broadcast addresses	Not applicable in IPv6
Unspecified address is 0.0.0.0	Unspecified address is ::
Loopback address is 127.0.0.1	Loopback address is ::1
Public IP addresses	Global unicast addresses
Private IP addresses (10.0.0.0/8, 172.16.0.0/12, and 192.168.0.0/16)	Site-local addresses (FEC0::/10)
Autoconfigured addresses (169.254.0.0/16)	Link-local addresses (FE80::/64)
Text representation: Dotted decimal notation	Text representation: Colon hexadecimal format with suppression of leading zeros and zero compression. IPv4-compatible addresses are expressed in dotted decimal notation.
Network bits representation: Subnet mask in dotted decimal notation or prefix length	Network bits representation: Prefix length notation only

ICMPv4 Error Messages and ICMPv6 Equivalents

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ICMPv4 Message	ICMPv6 Equivalent
Destination Unreachable-Network unreachable (Type 3, Code 1)	Destination Unreachable-No route to destination (Type 1, Code 0)
Destination Unreachable-Host unreachable (Type 3, Code 1)	Destination Unreachable-Address unreachable (Type 1, Code 3)
Destination Unreachable-Protocol unreachable (Type 3, Code 2)	Parameter Problem-Unrecognized Next Header field (Type 4, Code 1)
Destination Unreachable-Port unreachable (Type 3, Code 3)	Destination Unreachable-Port unreachable (Type 1, Code 4)
Destination Unreachable-Fragmentation needed and DF set (Type 3, Code 4)	Packet Too Big (Type 2, Code 0)
Destination Unreachable-Communication with destination host administratively prohibited (Type 3, Code 10)	Destination Unreachable-Communication with destination administratively prohibited (Type 1, Code 1)
Time Exceeded-TTL expired (Type 11, Code 0)	Time Exceeded-Hop Limit exceeded (Type 3, Code 0)
Time Exceeded-Fragmentation timer expired (Type 11, Code 1)	Time Exceeded-Fragmentation timer exceeded (Type 3, Code 1)
Parameter Problem (Type 12, Code 0)	Parameter Problem (Type 4, Code 0 or Code 2)
Source Quench (Type 4, Code 0)	This message is not present in IPv6.
Redirect (Type 5, Code 0)	Neighbor Discovery Redirect message (Type 137, Code 0).